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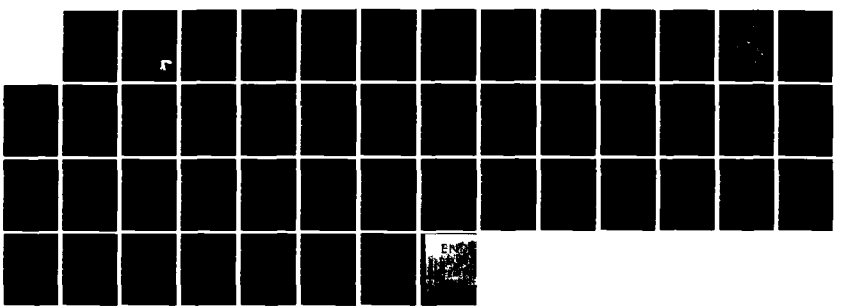

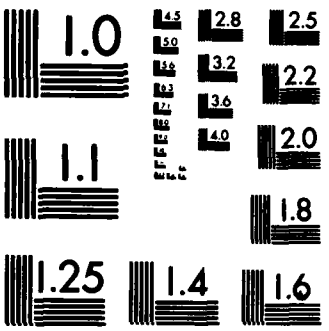

AFATL-TR-83-24

Benthic Macro-Invertebrates of Bull Creek and Ramer Branch, Eglin AFB Reservation

Joseph F Scheiring
Richard C Crews

ENVIRONICS OFFICE

MARCH 1983

FINAL REPORT FOR PERIOD AUGUST 1979—JUNE 1980

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Ramer Branch, Eglin AFB

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A baseline study of benthic macro-invertebrates was conducted in Bull Creek and Ramer Branch, two streams draining test ranges used for the testing and evaluation of conventional munitions. The purpose of this study was to determine the numbers and kinds of benthic macro-invertebrates inhabiting the streams. This included an analysis of community composition, trophic structure, and seasonal and annual diversity patterns. A total of 78 taxa (mostly genera) was collected from August 1979 to June 1980. Seventy-one taxa were collected by quantitative methods (Surber sampler) and seven additional taxa were collected by

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qualitative methods (light trap).

Aquatic insects made up 91 percent of the total macro-invertebrates collected. The Diptera were the most abundant group accounting for 49 percent of the total with the Chironomidae comprising from 38 to 46 percent of the total invertebrate fauna of each site. Other important groups included: Oligochaeta, Coleoptera, Trichoptera, Plecoptera, Odonata, and Ephermeroptera. The faunas at the sites were similar with sites sharing from 69 to 82 percent of their taxa. The differences in the fauna among stations are probably due to site differences.

The annual diversity values ranged from 5.041 to 4.386 while the evenness ranged from 0.908 to 0.819. The annual richness ranged from 51 to 43. The mean monthly diversity varied from 3.962 to 3.339 while the mean monthly evenness varied from 0.876 to 08.815. The mean monthly richness ranged from 23.5 to 18.7. The seasonal and annual patterns of diversity were most affected by the evenness components. The seasonal changes in community composition, richness, and evenness were due primarily to the life histories of the taxa and possibly drift.

The community trophic analysis showed that collectors and predators were dominant groups and had fairly constant abundances at all sites. The number of shredders was high while the numbers of filterers and scrapers were low. Functional group abundance and composition changed seasonally at each site due to the life histories of the individual insects and to stream conditions. The results of this study conform, generally, to the River Continuum model.

PREFACE

This technical report discusses a portion of the work performed at the Air Force Armament Laboratory, Armament Division, Eglin Air Force Base, Florida, under Exploratory Development Project 06AL0110 during the period July 1978 to June 1979.

The sources and manufacturers of materials and equipment used in this study are identified for reference only and do not constitute endorsement of the companies or products by the United States Air Force.

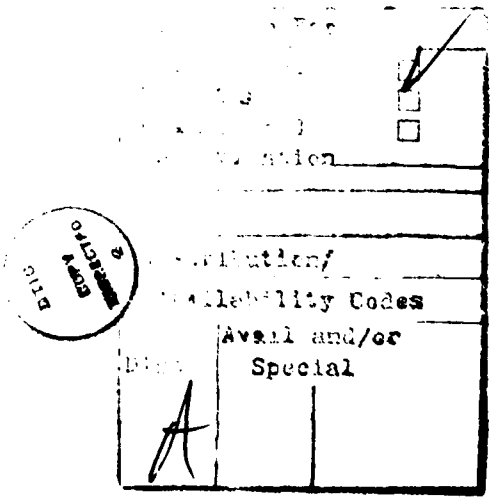
This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS), it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

Joe A. Farmer

JOE A. FARMER
Chief, Environics Office



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SECTION I

INTRODUCTION

Since November 1974, Air Force Armament Laboratory (AFATL) personnel have been engaged in an effort to establish the existing site characteristics for several Eglin AFB test areas. These test areas are utilized for the testing of conventional munitions. This effort was initiated to meet the Council of Environmental Quality (CEQ) guidelines and Air Force regulation requirements to establish the existing site characteristics of these test areas for environmental documentation.

Many streams originate on, flow through, or otherwise drain these test areas; therefore, an essential component of any site description is aquatic baseline data. For this reason, the study reported here was conducted. While this study was concerned with only one area of Eglin AFB, the Bull Creek and Ramer Branch drainage area, it does give an indication of the invertebrate fauna of the entire reservation. Previous studies on the invertebrates of Eglin AFB have been done on the benthic macro-invertebrates of Rocky Creek (Reference 1), the caddisfly fauna of Rocky and Bull creeks and Ramer Branch (Reference 2), and the terrestrial fauna of the base (Reference 3). Studies of the ichthyofauna of the area have also been previously published (References 4 and 5).

The purpose of this study was to determine the numbers and kinds of macro-invertebrates found in Bull Creek and Ramer Branch. This included an analysis of community composition, trophic structure, and seasonal and annual trends in diversity. This study presents some general statements about water quality in these streams and will be useful for comparison with future studies on the same area. All specimens were preserved and catalogued and a permanent reference collection is stored at the Environmental Research Facility, Building 574, Eglin Air Force Base. The remaining specimens are stored in the Aquatic Insect Collection of The University of Alabama.

SECTION II

DESCRIPTION OF THE STUDY AREA

Eglin AFB Reservation is located in northwest Florida and extends into Walton, Okaloosa, and Santa Rosa Counties. Most of the watersheds are sand hills with a pine/oak association. The soils are primarily acid sands of the Lakeland series. The streams in the area, including Bull Creek and Ramer Branch, are generally clear with moderate to fast flowing water. The stream bottoms are generally sand with detritus and leaf litter collecting along the channel edges and around patches of vegetation.

The three factors most significantly affecting water quality on Eglin AFB are climate, geomorphology and soil conditions and land use patterns. The effects of these factors have been discussed by Crews, et al (Reference 6).

Bull Creek and Ramer Branch, located in the east-central portion (northeast Okaloosa County) of the Reservation, were sampled at four sites (Figure 1). Sites 1 and 4 were on Bull Creek and sites 2 and 3 were on Ramer Branch. All sites were on second-order sections of the streams and were similar in size, depth, and substrate. All of the sites were fairly small, shallow, and had a heavy vegetative canopy.

Table 1 gives a summary of the physical and chemical conditions at each of the collection sites. In an earlier publication, Crews, et al (Reference 6) studies the physical and chemical conditions of selected streams and ponds on Eglin AFB, including some of the sites on Bull Creek and Ramer Branch used in the present study. They found few significant seasonal changes in conditions at any one site. A comparison of sites (Table 1) indicates that, overall, all sites are fairly similar with respect to most physio-chemical parameters measured. There are, however, some differences among the sites with respect to dissolved oxygen (D.O.), alkalinity, and chloride. This implies that the habitats available for macro-invertebrates differ somewhat among the sites.

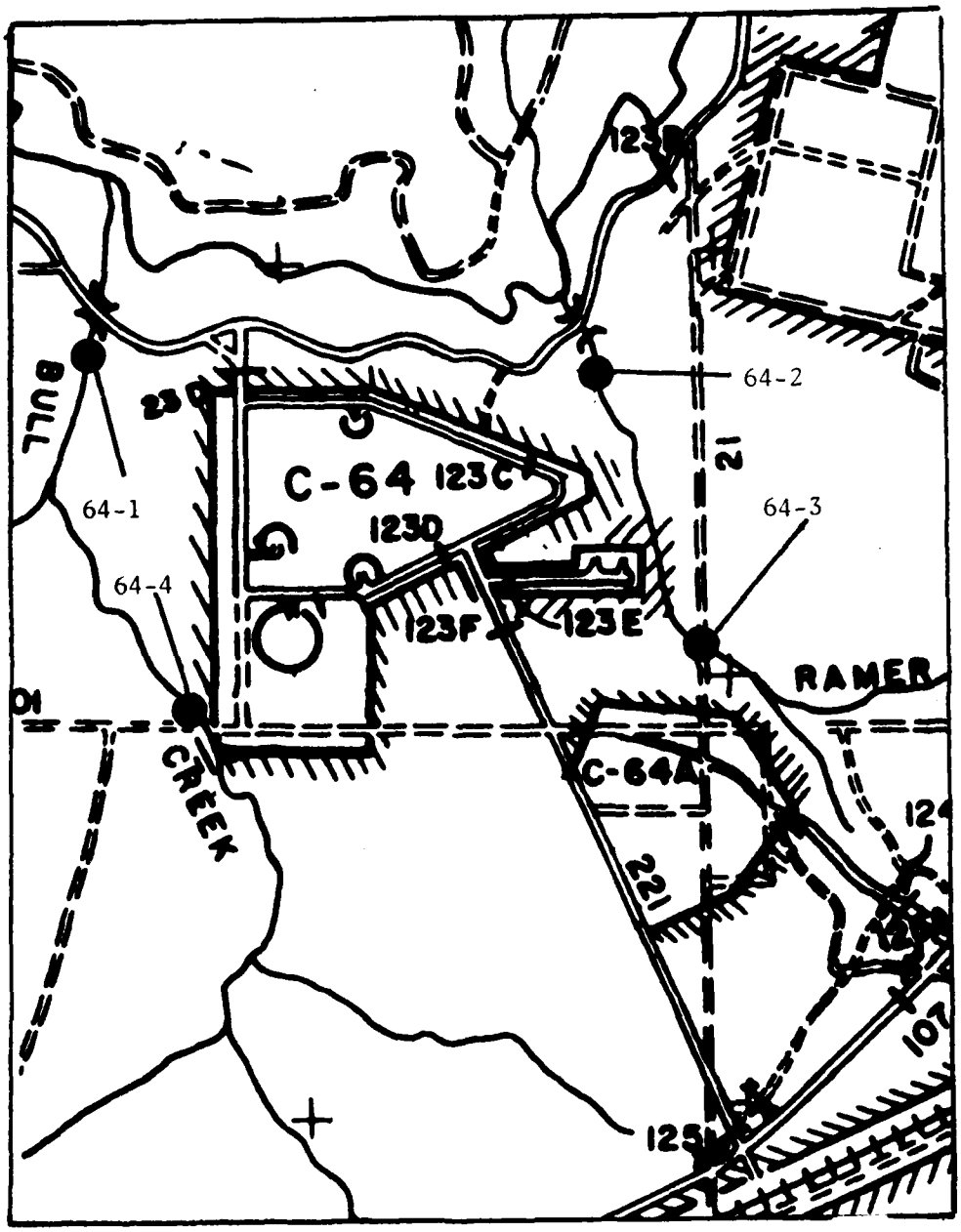

Figure 1. Map of Study Area on Bull Creek and Ramer Branch, Eglin AFB, Florida.

TABLE 1. MEAN VALUES FOR MEASURED PHYSICO-CHEMICAL PARAMETERS OF THE BULL CREEK AND RAMER BRANCH COLLECTION SITES.

Sites	Current* (cm/sec)	Temperature (°C)	Dissolved O_2 (ppm)	pH	Total Alkalinity (ppm)	Total Hardness ($CaCO_3$ ppm)	Chloride (NaCl ppm)
Bull Creek							
1	33.5	19.3	8.3	5.4	3.9	5.5	11.3
4	45.7	19.3	8.6	5.4	3.5	5.8	10.9
Ramer Branch							
2	45.7	19.1	8.4	5.1	3.9	6.1	11.2
3	45.7	19.1	8.8	5.5	4.1	5.9	11.5

MEASUREMENTS WERE TAKEN ONCE EVERY TWO MONTHS.

* Single reading, 16 August 1979.

SECTION III

MATERIALS AND METHODS

The four collection sites on Bull Creek and Ramer Branch were sampled once every two months from August 1979 to June 1980 for benthic macro-invertebrates with a 30.5 cm x 30.5 cm Surber sampler. Four samples of the substrate were taken at each station during each collection. Approximately 0.37 m^2 of substrate were sampled by these four samples. The density of benthic macro-invertebrates for each collection date at each site is reported as numbers/m^2 (see Appendix A). This was accomplished by multiplying the actual numbers collected by 2.7.

Qualitative samples were also taken at each site for most of the collection dates. Light traps were run monthly at each station during the course of this study, except in September and May, when semi-monthly collections were made. Kick samples, using a 1.6 mm mesh minnow seine, were taken at all stations during the first month of the study. This sampling method was discontinued for the remainder of the study due to manpower and time constraints. It is worth pointing out, however, that during the kick sampling in August 1979, nothing was collected that was not also collected by other sampling techniques. Both adult and immature macro-invertebrates were identified to genus in most cases.

As a measure of diversity, the Shannon-Wiener index (H') (Reference 7) was used because it incorporates both taxonomic richness and taxonomic evenness. This is calculated by:

$$H' = -\Sigma\, p_i \log_2 p_i \qquad (1)$$

where p_i is n/N
n_i is the number of individuals of the ith taxon of the collecting site being considered.
N is the total number of individuals per site.

Evenness (J') is calculated by:

$$J' = H'/\log_2 s \qquad (2)$$

where s is the taxonomic richness (number of taxa) per site.

Although Wilhm and Dorris (Reference 8), Olive and Dambach (Reference 9), and others have stated that H' is dimensionless and not affected by sample size (N), Sanders (Reference 10), Pielou (Reference 7), Fager (Reference 11), and Simberloff (Reference 12) have shown that this index is sensitive to sample size in many instances. However, no mathematically or conceptually sound alternative has been proposed. The sites in this study were sampled equally. The differences in sample sizes therefore probably reflect true biological differences among the sites (see Table 4). For this reason, no attempt was made to minimize the effect of sample size on the diversity index. Pearson produce-moment correlation coefficients were calculated to determine which of the components of diversity was most important.

Besides using annual and seasonal diversity trends to compare the community structure of the sites, a similarity index between each of the sites was calculated to determine what proportion of the taxa the sites shared. This index (I) was calculated by:

$$I = 2C/A + B \qquad (3)$$

where C is the number of taxa found at both sites.
A is the number of taxa found at site A.
B is the number of taxa found at site B.

An analysis of the community trophic structure at each of the sites was also performed. The functional group method of Merritt and Cummins (Reference 13) was used to assign each taxon of macro-invertebrates to a trophic category. The sites were then compared with respect to the densities of various functional groups.

SECTION IV

RESULTS

1. COMMUNITY COMPOSITION

During the course of this study, 3354 benthic macro-invertebrates representing 71 taxa were collected using the Surber sampler (Table 2). Another 7 taxa were collected using qualitative methods (Table 3). Therefore, a total of 78 taxa (mostly genera) was found in Bull Creek and Ramer Branch. Appendix A lists the densities of each taxon at each station for each month. In the quantitative samples, aquatic insects made up 91 percent of the total number and the remainder was made up of crustaceans and oligochaets. Of the insects, the Diptera were the most abundant, accounting for 49 percent of the total invertebrates collected, with the Chironomidae comprising from 38 to 46 percent of the total invertebrate fauna of each site. Other abundant groups include the Trichoptera (11.7 percent), Coleoptera (11.4 percent), Ephemeroptera (8.2 percent), Odonata (6.8 percent), Plecoptera (4.4 percent), and Oligochaeta (4.4 percent). In the light traps, the dominant group was the Trichoptera.

Table 2 also shows that only a small number of genera are abundant and common to all sites. As mentioned earlier, the Chironomidae were very abundant at all sites, especially Site 2. The most commonly found chironomids were Ablabesmyia sp., Cryptochironomus sp., Eukiefferiella sp., Polypedilum sp., Rheotanytarsus sp., and Thienemannimyia sp. The other commonly encountered invertebrates were: Hexatoma sp. (Diptera); Stenelmis sp. (Coleoptera); Anisocentropus sp., Oecetis sp., and Agarodes sp. (Trichoptera); Allocapnia sp. (Plecoptera); Gomphus sp. (Odonata); Hexagenia sp. and Ephemerella sp. (Ephemeroptera); and Oligochaeta (Annelida). Most of the uncommon or rare species were usually found at only one or two sites but occasionally they were found in low numbers at all of the sites.

Differences in the distribution of genera are indicative of differences in habitat. As previously mentioned, the data in Table 1 indicate that there are habitat differences among the sites. However, differences in a fauna that is composed mostly of rare and uncommon genera can lead to incorrect conclusions about habitat differences if care is not taken in the interpretation of data. If a taxon is rare, and is not collected at a site, this might mean that it cannot live there because the habitat is not suitable. It could, however, also mean that the taxon does live there but the sampling methods used failed to collect it. For this reason, differences in abundances of the more common taxa should be given more weight when talking about habitat differences among sites. In spite of the numerous rare taxa, an analysis of similarity (Table 4) between sites shows that the faunas of the sites were very similar and that each site shared from 69 to 82 percent of its fauna with every other site.

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FOUR SITES IN BULL CREEK AND RAMER BRANCH (QUANTITATIVE SAMPLES ONLY).

Taxa	Trophic Relationship	Total Numbers	Percent Composition			
			Site 1	Site 2	Site 3	Site 4
ARTHROPODA		3205	96.27	96.32	95.41	93.51
INSECTA		3064	92.61	94.41	86.58	89.00
DIPTERA		1637	49.69	51.21	41.70	50.07
Ceratopogonidae	Predators	66	2.04	2.94	1.06	1.27
Chironomidae		1459	42.49	46.37	38.16	45.70
Ablabesmyia sp.	Predators	111	4.53	2.73	1.94	3.24
Cardiocladius sp.	Predators	6	--*	--	--	--
Chironomus sp.	Collectors	4	--	0.42	--	--
Clinotanypus sp.	Predators	63	0.18	2.73	6.18	--
Cryptochironomus sp.	Predators	115	1.69	5.26	4.42	2.96
Eukiefferiella sp.	Collectors/Predators	378	12.89	11.36	8.83	10.58
Microtendipes sp.	Collectors	8	0.71	--	--	--
Parachironomus sp.	Predators/Collectors	6	--	--	1.06	--
Paralauterborniella sp.	Collectors	4	0.36	--	--	--
Paratendipes sp.	Collectors	6	0.36	--	0.35	--
Phaenospectra sp.	Collectors	74	1.24	3.89	2.30	1.41
Polypedilum sp.	Collectors	172	0.89	5.57	3.00	12.98
Procladius sp.	Predators	80	0.80	4.84	2.30	1.69
Pseudochironomus sp.	Collectors	4	--	0.42	--	--
Rheotanytarsus sp.	Collectors	137	5.24	3.89	1.77	4.37
Stenochironomus sp.	Collectors	11	--	--	0.18	1.41
Stictochironomus sp.	Collectors	6	--	--	--	0.85
Tanypus sp.	Predators/Collectors	4	--	--	0.71	0.28
Thienemannimyia sp.	Predators	108	3.11	4.10	4.59	1.13
Unidentified Genera		140	10.49	--	--	3.10
Tabanidae		4	0.09	--	0.18	0.28
Chrysops sp.	Collectors	1	--	--	0.18	--
Tabanus sp.	Predators	3	0.09	--	--	0.28

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FOUR SITES IN BULL CREEK AND RAMER BRANCH (QUANTITATIVE SAMPLES ONLY). (CONTINUED)

Taxa	Trophic Relationship	Total Numbers	Percent Composition			
			Site 1	Site 2	Site 3	Site 4
Tipulidae		107	4.98	1.90	2.30	2.82
Brachypremna sp.	Shredders	7	0.36	0.21	--	0.14
Hexatoma sp.	Predators	83	3.64	1.37	2.12	2.40
Limnophila sp.	Predators	13	0.62	0.32	0.18	0.28
Tipula sp.	Shredders	4	0.36	--	--	--
Simuliidae		1	0.09	--	--	--
Simulium sp.	Filterers	1	0.09	--	--	--
TRICHOPTERA		392	13.79	8.33	14.14	11.00
Brachycentridae		8	0.18	0.11	0.18	0.56
Brachycentrus sp.	Filterers	6	--	0.11	0.18	0.56
Micrasema sp.	Shredders	2	0.18	--	--	--
Calamoceratidae		64	1.16	1.37	4.06	2.12
Anisocentropus sp.	Shredders	64	1.16	1.37	4.06	2.12
Hydropsychidae		33	0.89	2.21	0.18	0.14
Cheumatopsyche sp.	Filterers	10	0.89	--	--	--
Diplectrona sp.	Filterers	3	--	0.32	--	--
Hydropsyche sp.	Filterers	20	--	1.89	0.18	0.14
Macronema sp.	Filterers	--	--	--	--	--
Potamyia sp.	Filterers	--	--	--	--	--
Hydroptilidae		10	--	0.21	0.53	0.71
Hydroptila sp.	Herbivores/Scrapers	10	--	0.21	0.53	0.71
Leptoceridae		54	0.98	0.95	3.71	1.83
Oecetis sp.	Predators	48	0.71	0.63	3.71	1.83
Triaenodes sp.	Shredders	6	0.27	0.32	--	--
Molannidae		2	--	--	0.35	--
Molanna sp.	Scrapers	2	--	--	0.35	--
Philopotamidae		3	0.09	0.21	--	--
Chimarra sp.	Filterers	3	0.09	0.21	--	--

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FOUR SITES IN BULL CREEK AND RAMER BRANCH (QUANTITATIVE SAMPLES ONLY). (CONTINUED)

Taxa	Trophic Relationship	Total Numbers	Percent Composition			
			Site 1	Site 2	Site 3	Site 4
Phryganeidae		3	--	0.32	--	--
Ptilostomis sp.	Shredders	3	--	0.32	--	--
Polycentropodidae		5	0.36	0.11	--	--
Cyrnellus sp.	Filterers	4	0.36	--	--	--
Polycentropus sp.	Predators	1	--	0.11	--	--
Rhyacophilidae		2	0.09	--	0.18	--
Rhyacophila sp.	Predators	2	0.09	--	0.18	--
Sericostomatidae		208	10.04	2.84	4.95	5.64
Agarodes sp.	Shredders	208	10.04	2.84	4.95	5.64
COLEOPTERA		382	16.00	4.32	9.55	14.67
Dryopidae		5	0.18	--	0.53	--
Helichus sp.	Shredders	5	0.18	--	0.53	--
Dytiscidae		1	--	--	0.18	--
Hydroporus sp.	Predators	1	--	--	0.18	--
Elmidae		366	15.73	4.00	8.31	14.67
Dubiraphia sp.	Collectors	1	--	--	0.18	--
Stenelmis sp.	Collectors	365	15.73	4.00	8.13	14.67
Gyrinidae		5	0.09	0.11	--	--
Dineutes sp.	Predators	5	0.09	0.11	--	--
Psephenidae		5	--	0.21	0.53	--
Psephenus sp.	Scrapers	5	--	0.21	0.53	--
EPHEMEROPTERA		276	6.93	14.10	7.07	3.39
Baetiscidae		18	--	0.42	0.71	1.41
Baetisca sp.	Collectors	18	--	0.42	0.71	1.41
Baetidae		23	1.24	--	0.71	0.71
Baetis sp.	Collectors	23	1.24	--	0.71	0.71

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FOUR SITES IN BULL CREEK AND RAMER BRANCH (QUANTITATIVE SAMPLES ONLY). (CONTINUED)

Taxa	Trophic Relationship	Total Numbers	Percent Composition			
			Site 1	Site 2	Site 3	Site 4
Ephemerellidae		57	2.13	0.74	3.18	1.13
Danella sp. **	Collectors	57	2.13	0.74	3.18	1.13
Ephemeridae		162	2.58	12.41	2.47	0.14
Hexagenia sp.	Collectors	162	2.58	12.41	2.47	0.14
Heptageniidae		16	0.98	0.53	--	--
Stenonema sp.	Collectors	16	0.98	0.53	--	--
ODONATA		228	2.05	12.00	10.42	4.71
Coenagrionidae		5	0.09	0.11	0.35	0.14
Enallagma sp.	Predators	5	0.09	0.11	0.35	0.14
Cordulegastridae		1	--	--	0.18	--
Cordulegaster sp.	Predators	1	--	--	0.18	--
Gomphidae		219	1.69	11.89	9.89	4.57
Gomphus sp.	Predators	202	1.51	10.94	9.01	4.23
Progomphus sp.	Predators	17	0.18	0.95	0.88	0.14
Macromiidae		3	0.27	--	--	--
Macromia sp.	Predators	3	0.27	--	--	--
PLECOPTERA		148	4.09	4.52	3.71	9.07
Capniidae		142	4.00	4.31	3.53	5.08
Allocapnia sp.	Shredders	142	4.00	4.31	3.53	5.08
Perlidae		6	0.09	0.21	0.18	0.28
Perlesta sp.	Predators	6	0.09	0.21	0.18	0.28
HEMIPTERA						
Veliidae						
Rhagovelia	Predators	1	0.09	--	--	--
CRUSTACEA		141	3.66	1.91	8.83	4.51
DECAPODA		74	3.12	1.06	2.47	2.11
Palaemonetes sp.	Filterers	10	0.36	0.11	0.53	0.28
Procambarus sp.	Generalist	64	2.76	0.95	1.94	1.83

TABLE 2. ACTUAL AND RELATIVE ABUNDANCES OF BENTHIC MACRO-INVERTEBRATES COLLECTED AT FOUR SITES IN BULL CREEK AND RAMER BRANCH (QUANTITATIVE SAMPLES ONLY). (CONCLUDED)

Taxa	Trophic Relationship	Total Numbers	Percent Composition			
			Site 1	Site 2	Site 3	Site 4
ISOPODA		27	0.36	0.53	2.83	0.28
Asellus sp.	Shredders/Scavengers	27	0.36	0.53	2.83	0.28
AMPHIPODA		40	0.18	0.32	3.53	2.12
Gammarus sp.	Shredders/Scavengers	40	0.18	0.32	3.53	2.12
ANNELIDA		149	3.73	3.68	4.59	6.49
OLIGOCHAETA	Collectors	149	3.73	3.68	4.59	6.49

TOTAL NUMBER OF INVERTEBRATES COLLECTED WAS 3354. TROPHIC RELATIONSHIPS (FUNCTIONAL GROUPS) ARE BASED ON MERRITT AND CUMMINS (REFERENCE 13).

* Dash indicates that taxon was not collected at this site.

** Formerly included in the genus *Ephemerella*.

TABLE 3. MACRO-INVERTEBRATES COLLECTED BY QUALITATIVE (LIGHT TRAP) METHODS AND NOT COLLECTED IN ANY OF THE QUANTITATIVE (SURBER SAMPLER) SAMPLES.

Taxa	Trophic Relationship	Site 1	Site 2	Site 3	Site 4
TRICHOPTERA					
Hydropsychidae					
Macronema sp.	Filterers	L	--*	L	--
Leptoceridae					
Ceraclea sp.	Collectors	L	--	L	--
Nectopsyche sp.	Shredders	L	L	L	L
Triaenodes sp.	Shredders	L	--	L	--
Polycentropodidae					
Neureclipses sp.	Filterers	--	--	L	--
Nyctiophylax sp.	Predators	L	--	--	L
PLECOPTERA					
Perlidae					
Acroneuria sp.	Predators	--	--	--	L

TROPHIC RELATIONSHIPS (FUNCTIONAL GROUPS) ARE BASED ON MERRITT AND CUMMINS (REFERENCE 13).

* Dash indicates that taxon was not collected at this site.

TABLE 4. SIMILARITY INDICES BETWEEN BULL CREEK AND RAMER BRANCH STUDY SITES.

	Site 1	Site 2	Site 3	Site 4
Site 1	--*	0.70	0.69	0.67
Site 2	0.73	--	0.72	0.80
Site 3	0.69	0.76	--	0.76
Site 4	0.70	0.81	0.82	--

THE UPPER RIGHT VALUES ARE SIMILARITIES BASED ON BOTH QUANTITATIVE (SURBER SAMPLER) AND QUALITATIVE (LIGHT TRAP AND KICK SAMPLE) COLLECTIONS. THE LOWER LEFT VALUES ARE SIMILARITIES BASED ON QUANTITATIVE COLLECTIONS ONLY.

* Dash indicates that taxon was not collected at this site.

2. COMMUNITY DIVERSITY

The sites and their annual values of s, H', J', and N are given in Table 5. All diversity values are extremely high and indicative of very high water quality. Site 1 had the highest diversity, while Site 4 had the lowest. The other two sites had intermediate diversities. When only the quantitative samples are considered, Site 1 had the greatest number of genera while Site 2 had the fewest. When all samples are considered, Sites 1 and 2 have the most genera and Site 4 the least. Site 1 had the highest evenness and Site 2 the lowest.

These results suggest that even though both richness and evenness contribute to the diversity measure, evenness is more important in determining H'. The correlation coefficients calculated between H' and J', s, and N support this contention. Only J' was significantly correlated with H' ($r = 0.984$, $p \leq .05$). Although s did not have a significant correlation with H', it did have a high correlation ($r = 0.882$, $.05 < p \leq .1$). There was no significant correlation between H' and N ($r = 0.417$, $p > .05$) indicating that sample size did not affect diversity in this study. Correlations of the physico-chemical parameters from Table 1 with annual diversity, richness, and evenness produced no significant relationships, possibly because of the small number of degrees of freedom in the analysis.

Seasonal patterns of taxonomic diversity at each of the sites are given in Table 6. Sites 1, 2, and 4 have the highest diverstiy in December while Site 3 had the highest diversity in February. The lowest diversities were found in either April or June. The uncharacteristically low diversities for Site 4 in April and Site 1 in June were due mainly to the fact that all Chironomidae were counted as only one taxon. Because the Chironomidae were such a dominant group, their inclusion as only one taxon made for a very uneven distribution of abundance among the taxa at these two sites, thus lowering the diversity measure. These low diversities should be considered as artifacts of the diversity equation and not as indicators of lowered water quality at these stations in April and June.

Seasonal patterns of taxonomic richness at each of the sites are given in Table 7. When considering only the quantitative samples, all of the sites had the highest number of genera in October, December, or February. This result does not change when all samples are considered. Richness then declines in the Spring and Summer and begins to increase again in the Fall and Winter. Seasonal patterns of taxonomic evenness at the sites are given in Table 8. The highest evenness values were in December for all sites, while the lowest values were in April or June.

TABLE 5. BULL CREEK AND RAMER BRANCH COLLECTION SITES AND THEIR ANNUAL VALUES OF TAXONOMIC RICHNESS (s), DIVERSITY (H'), EVENNESS (J') AND SAMPLE SIZE (N).

Site	s	H'	J'	N
1	47 (51)	5.041	0.908	1125
2	44 (45)	4.469	0.819	951
3	45 (51)	4.770	0.864	566
4	40 (43)	4.386	0.824	709

NUMBERS IN PARENTHESES ARE RICHNESS VALUES THAT INCLUDE LIGHT TRAP AND KICK SAMPLE COLLECTIONS FOR s.

TABLE 6. SEASONAL PATTERNS OF INVERTEBRATE TAXONOMIC DIVERSITY (H') AT THE BULL CREEK AND RAMER BRANCH COLLECTION SITES BASED ON QUANTITATIVE (SURBER SAMPLER) SAMPLES.

Sites	Aug	Oct	Dec	Feb	April	June	mean H' / mo.
1	3.641	3.395	4.390	3.944	3.440	2.295*	3.518
2	3.667	3.955	4.075	3.855	3.787	3.588	3.821
3	nc	3.998	4.087	4.215	3.598	3.910	3.962
4	3.382	3.567	3.785	3.759	2.236*	3.306	3.339

* All Chironomidae counted as one taxon because condition of specimens made generic identification impossible.

nc no collection.

TABLE 7. SEASONAL PATTERNS OF INVERTEBRATE TAXONOMIC RICHNESS (s) AT THE BULL CREEK AND RAMER BRANCH COLLECTION SITES BASED ON QUANTITATIVE (SURBER SAMPLER) SAMPLES.

Sites	Aug	Oct	Dec	Feb	April	June	mean s / mo.
1	22 (28)	18 (18)	32 (32)	25 (25)	17 (17)	15* (15*)	21.5 (22.5)
2	24 (27)	28 (28)	24 (24)	23 (23)	21 (21)	18 (18)	23.0 (23.5)
3	nc	22 (22)	25 (25)	28 (28)	18 (18)	23 (23)	23.2 (23.2)
4	15 (21)	17 (17)	22 (22)	21 (21)	9* (9*)	22 (22)	17.7 (18.7)

NUMBERS IN PARENTHESES ARE RICHNESS VALUES THAT INCLUDE LIGHT TRAP AND KICK SAMPLE COLLECTIONS.

* All Chironomidae counted as one taxon because condition of specimens made generic identification impossible.

nc no collection.

TABLE 8. SEASONAL PATTERNS OF INVERTEBRATE TAXONOMIC EVENNESS (J') AT THE BULL CREEK AND RAMER BRANCH COLLECTION SITES BASED ON QUANTITATIVE (SURBER SAMPLER) SAMPLES.

Sites	Aug	Oct	Dec	Feb	April	June	mean J' / mo.
1	0.816	0.814	0.878	0.849	0.842	0.587*	0.798
2	0.800	0.823	0.889	0.852	0.862	0.860	0.848
3	nc	0.897	0.880	0.877	0.863	0.864	0.876
4	0.866	0.873	0.849	0.856	0.705*	0.741	0.815

* All Chironomidae counted as one taxon because condition of specimens made generic identification impossible.

nc no collection.

3. COMMUNITY TROPHIC STRUCTURE

Tables 2 and 3 give the trophic category or functional groups of each of the taxa. These trophic relationships are classified primarily according to feeding mechanism rather than food eaten. Their use in this report has been slightly modified from that of Merritt and Cummins (Reference 13). They are defined as follows:

Shredders	-	Feed on decomposing vascular plant tissues--coarse particulate organic matter (CPOM). Primarily chewers and wood borers (detritivores).
Collectors	-	Feed on decomposing animal and plant fine particulate organic matter (FPOM). Mostly gathers or deposit (sediment) feeders (detritivores).
Filterers	-	Feed on decomposing animal and/or plant FPOM. Filter or suspension feeders (detritivores).
Scrapers	-	Feed by scraping attached periphyton from mineral and organic surfaces.
Predators	-	Feed on living animal tissue. Either eat animals whole or pierce tissues and cells and suck fluids.
Herbivores	-	Feed on living hydrophyte plant tissue. Either chew on plant or pierce tissues and cells and suck fluids.
Generalists	-	Feed on a variety of living and non-living plant and animal foods.
Scavengers	-	Feed on dead plant and animal tissues of various sizes.

The relative abundances of the major functional groups found at each of the sites in Bull Creek and Ramer Branch are given in Table 9. These data show that collectors and predators were the dominant groups and had fairly constant abundances at sites within streams. Since all of the sites were low-order streams with heavy canopies, the River Continuum Model (Reference 14) predicts that there should be large numbers of collectors, predators, and shredders, and low numbers of filterers and scrapers. Our results generally conform to the predictions of this model.

TABLE 9. RELATIVE ABUNDANCES OF MAJOR FUNCTIONAL GROUPS COLLECTED AT FOUR SITES IN BULL CREEK AND RAMER BRANCH BASED ON QUANTITATIVE (SURBER SAMPLER) COLLECTIONS ONLY.

Functional Groups	Percent Composition Site 1	Site 2	Site 3	Site 4
Shredders	17.09	10.23	19.43	15.38
Collectors (Gatherers)	54.37	48.51	37.11	58.86
Filterers	1.79	2.53	0.89	0.98
Scrapers	0.00	0.42	1.41	0.71
Predators	23.98	37.35	39.23	22.24
Generalists	2.76	0.95	1.94	1.83

SECTION V

DISCUSSION

Although similarity indices (Table 4) between sites indicated that most of the fauna at each of the sites were similar, Table 2 showed that the abundances of the various taxa were not always similar. Physico-chemical factors (Table 1), and diversity values (Table 5) showed that the sites were somewhat different in their habitat and community structure. The analysis of community diversity indicates that both seasonally and annually the diversity of all sites is extremely high. The most important factor affecting diversity was the evenness component, with lower evenness resulting from high densities of certain taxa. The number of taxa did not vary much from site to site, except for Site 4. Evenness is also quite high at all stations throughout most of the year. This indicates that there are very few really dominant taxa at the sites. It is interesting to note that diversity, evenness, and to some extent, richness all seem to peak in the winter. This is not an unexpected result, since emergence of adults occurs primarily in spring and summer thus changing the community composition of the immatures in the stream. The seasonal changes in community structure and composition are therefore primarily due to the life cycles (emergence, drift, egg diapause, etc.) of the taxa and, to a lesser extent, to changes in stream conditions.

As stated earlier, the results of the trophic analysis of the communities were as predicted by the River Continuum Model. All of the sites were shallow and had heavy canopies resulting in large amounts of Course Particulate Organic Matter (CPOM) entering the stream. The amount of CPOM compared to the stream area is larger in smaller streams than in larger (higher order) streams. Therefore the number of shredders per unit area of small streams is higher than in larger streams. The collectors and predators should remain constant because their food source remains constant. In larger streams the canopy is more open allowing more sunlight to reach the water with a resultant increase in periphyton growth. Thus the numbers of scrapers increase. Filterers become more abundant in larger streams because the faster current allows them to filter the Fine Particulate Organic Matter (FPOM) produced by the action of shredders upstream. Thus the filterers and scrapers remain in low numbers at the study sites.

The presence of Chironomidae has often been associated with poor water quality. This is true if Chironomidae are the only organisms found. When Chironomidae are found in association with a wide range of other organisms, as was the case in this study, a different interpretation must be made. The sandy substrate limits the kinds of organisms that can live in the stream and is most favorable for Diptera, especially Chironomidae. Considering the physico-chemical parameter values, the numbers and kinds of organisms found, and their diversity, evenness, and trophic structure, it must be concluded that the water quality of Bull Creek and Ramer Branch is extremely high. The presence of numerous genera of Trichoptera and the abundance of the stonefly Allocapnia reinforce this conclusion. The high diversity of Chironomidae is primarily a function of the sandy substrate and not of water quality.

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APPENDIX A

DENSITIES OF BENTHIC MACRO-INVERTEBRATES BY COLLECTION SITE AND DATE

Density (no./m^2) of benthic macro-invertebrates in Bull Creek and Ramer Branch at each site for each collection. Entries of L (light trap) or K (kick sample) indicate that taxon was only collected at that time and place by qualitative sampling methods.

SITE #1

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
DIPTERA								
Ceratopogonidae	8.1	**	13.5	27.0	5.4	5.4		2.7
Chironomidae								
Ablabesmyia sp.			59.4	78.3				
Clinotanypus sp.						5.4		
Cryptochironomus sp.	5.4		13.5		16.2	16.2		
Eukiefferiella sp.			132.3	21.6	56.7	43.2		
Microtendipes sp.				21.6				
Paralauterborniella sp.				10.8				
Paratendipes sp.				10.8				
Phaenospectra sp.				21.6	16.2			
Polypedilum sp.				10.8	16.2			
Procladius sp.			13.5	10.8				
Rheotanytarsus sp.			13.5	113.4	32.4			
Thienemannimyia sp.	2.7		24.3	45.9	16.2	5.4		
Unidentified Genera								318.6
Tabanidae								
Tabanus sp.						2.7		
Tipulidae								
Brachypremna sp.								10.8
Hexatoma sp.	13.5		13.5	24.3	35.1	10.8		13.5
Limnophila sp.	10.8		5.4		2.7			
Tipula sp.	5.4		2.7		2.7			
Simuliidae								
Simulium sp.						2.7		

SITE #1 (continued)

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
COLEOPTERA								
Dryopidae								
Helichus sp.	2.7			2.7				
Elmidae								
Stenelmis sp.	59.4		48.6	67.5	18.9	43.2		240.3
Gyrinidae								
Dineutes sp.								2.7
TRICHOPTERA								
Brachycentridae								
Brachycentrus sp.							L	
Micrasema sp.	5.4							
Calamoceratidae								
Anisocentropus sp.	10.8 (K)	L		16.2	2.7	2.7	L	2.7
Hydropsychidae								
Cheumatopsyche sp.	2.7 (L)	L		24.3			L	
Hydropsyche sp.	K,L	L					L	
Macronema sp.							L	
Hydroptilidae								
Hydroptila sp.							L	
Leptoceridae								
Ceraclea sp.							L	
Nectopsyche sp.		L					L	
Oecetis sp.	2.7	L		13.5	5.4		L	
Triaenodes sp.				8.1			L	
Molannidae								
Molanna sp.		L					L	
Philopotamidae								
Chimarra sp.		L		2.7			L	
Polycentropodidae								
Cyrnellus sp.				8.1	2.7			
Nyctiophylax sp.							L	

SITE #1 (continued)

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
Rhyacophilidae								
Rhyacophila sp.		L		2.7			L	
Sericostomatidae								
Agarodes sp.	56.7 (L)	L	86.4	24.3	27.0	40.5	L	70.2
PLECOPTERA								
Capniidae								
Allocapnia sp.	54.0		13.5	43.2				10.8
Perlidae								
Perlesta sp.					2.7			
ODONATA								
Coenagrionidae								
Enallagma sp.	K							2.7
Gomphidae								
Gomphus sp.	13.5 (K)		13.5	5.4	2.7	2.7		8.1
Progomphus sp.	2.7 (K)				2.7			
Macromiidae								
Macromia sp.	K			5.4	2.7			
EPHEMEROPTERA								
Baetidae								
Baetis sp.	8.1		2.7	10.8	5.4	5.4		5.4
Ephemerellidae								
Danella sp.				48.6	8.1			8.1
Ephemeridae								
Hexagenia sp.			16.2	5.4	48.6	8.1		
Heptageniidae								
Stenonema sp.	8.1			18.9	2.7			
HEMIPTERA								
Veliidae								
Rhagovelia sp.	2.7							

SITE #1 (concluded)

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
CRUSTACEA								
Decapoda								
Palaemonetes sp.	K					10.8		
Procambarus sp.	18.9 (K)		2.7	16.2	2.7	35.1		8.1
Isopoda								
Asellus sp.	10.8							
Amphipoda								
Gammarus sp.	2.7			2.7				
ANNELIDA								
Oligochaeta	K		21.6	16.2	13.5	8.1		54.0

SITE #2

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
DIPTERA								
Ceratopogonidae			40.5	13.5	5.4	2.7		13.5
Chironomidae								
Ablabesmyia sp.			18.9	29.7		10.8		10.8
Chironomus sp.				10.8				
Clinotanypus sp.			35.1	21.6	8.1	5.4		
Cricotopus sp.	18.9			10.8				
Cryptochironomus sp.	5.4		18.9	10.8	45.9	18.9		35.1
Eukiefferiella sp.	113.4		54.0	45.9	8.1	2.7		67.5
Phaenospectra sp.	5.4		18.9	45.9		8.1		21.6
Polypedilum sp.	27.0			67.5	18.9	8.1		21.6
Procladius sp.				35.1	37.8	54.0		45.9
Pseudochironomus sp.				10.8				
Rheotanytarsus sp.	32.4		35.1	21.6				10.8
Thienemannimyia sp.	27.0		18.9	21.6	8.1	18.9		10.8
Tipulidae								
Brachypremna sp.			5.4					
Hexatoma sp.			2.7	10.8	10.8			10.8
Limnophila sp.			2.7	5.4				
COLEOPTERA								
Elmidae								
Stenelmis sp.	13.5	L	16.2	5.4	10.8	5.4		51.3
Gyrinidae								
Dineutes sp.								2.7
Psephenidae								
Psephenus sp.			5.4					
TRICHOPTERA								
Brachycentridae								
Brachycentrus sp.			2.7					
Calamoceratidae								
Anisocentropus sp.	2.7		2.7	10.8	8.1	2.7		8.1

SITE #2 (continued)

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
Hydropsychidae								
Cheumatopsyche sp.		L						
Diplectrona sp.	5.4			2.7				
Hydropsyche sp.	5.4	L	21.6		21.6			
Hydroptilidae								
Hydroptila sp.	5.4							
Leptoceridae								
Nectopsyche sp.							L	
Oecetis sp.	2.7	L	10.8	2.7			L	
Triaenodes sp.	8.1							
Philopotamidae								
Chimarra sp.		L	2.7		2.7			
Phryganeidae								
Ptilostomis sp.								8.1
Polycentropodidae								
Polycentropus sp.			2.7					
Sericostomatidae								
Agarodes sp.	54.0	L	10.8	2.7	2.7	2.7		
PLECOPTERA								
Capniidae								
Allocapnia sp.	27.0		78.3		2.7	2.7		
Perlidae								
Perlesta sp.				5.4	8.1			
ODONATA								
Coenagrionidae								
Enallagma sp.	2.7							
Gomphidae								
Gomphus sp.	113.4 (K)		64.8	21.6	45.9	27.0		8.1
Progomphus sp.	K		2.7	10.8	2.7	8.1		

SITE #2 (concluded)

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
EPHEMEROPTERA								
Baetiscidae								
Baetisca sp.			5.4			5.4		
Ephemerellidae								
Danella sp.	5.4		2.7		8.1	2.7		
Ephemeridae								
Hexagenia sp.	K		126.9	67.5	81.0	43.2		
Heptageniidae								
Stenonema sp.	5.4				8.1			
CRUSTACEA								
Decapoda								
Palaemonetes sp.	K					2.7		
Procambarus sp.	5.4 (K)		5.4			8.1		5.4
Isopoda								
Asellus sp.	13.5							
Amphipoda								
Gammarus sp.	5.4				2.7			
ANNELIDA								
Oligochaeta	40.5 (K)		16.2	13.5	21.6	2.7		

SITE #3

Taxa	Collection Dates (1979-80) Aug***	Sept*	Oct	Dec	Feb	April	May*	June
DIPTERA								
Ceratopogonidae			5.4		5.4	2.7		2.7
Chironomidae								
Ablabesmyia sp.			2.7		16.2			10.8
Clinotanypus sp.					5.4	5.4		83.7
Cricotopus sp.				8.1				
Cryptochironomus sp.			5.4	8.1	27.0	5.4		21.6
Eukiefferiella sp.			37.8	28.0				21.6
Parachironomus sp.					5.4			10.8
Paratendipes sp.					5.4			
Phaenospectra sp.				8.1	5.4			21.6
Polypedilum sp.			2.7	16.2	5.4			21.6
Procladius sp.			2.7	16.2	5.4			10.8
Rheotanytarsus sp.			10.8		5.4			10.8
Stenochironomus sp.			2.7					
Tanypus sp.								10.8
Thienemannimyia sp.			10.8		21.6			37.8
Tabanidae								
Chrysops sp.				2.7				
Tipulidae								
Hexatoma sp.			10.8	13.5		5.4		2.7
Limnophila sp.						2.7		
COLEOPTERA								
Dryopidae								
Helichus sp.			8.1					
Dytiscidae								
Hydroporus sp.						2.7		
Elmidae								
Dubiraphia sp.			2.7					
Stenelmis sp.		L	37.8	29.7	16.2	18.9		21.6

SITE #3 (continued)

Taxa	Collection Dates (1979-80) Aug***	Sept*	Oct	Dec	Feb	April	May*	June
Psephenidae								
Psephenus sp.					5.4			2.7
TRICHOPTERA								
Brachycentridae								
Brachycentrus sp.				2.7				
Micrasema sp.							L	
Calamoceratidae								
Anisocentropus sp.			27.0	12.0		2.7		
Hydropsychidae								
Cheumatopsyche sp.		L					L	
Hydropsyche sp.		L		2.7			L	
Macronema sp.	L							
Potamyia sp.								
Hydroptilidae								
Hydroptila sp.		L			8.1		L	
Leptoceridae								
Ceraclea sp.							L	
Nectopsyche sp.							L	
Oecetis sp.	L	L	8.1	10.8	27.0		L	10.8
Triaenodes sp.	L						L	
Molannidae								
Molanna sp.				5.4				
Philopotamidae								
Chimarra sp.	L	L					L	
Polycentropodidae								
Neureclipses sp.		L						
Rhyacophilidae								
Rhyacophila sp.						2.7		
Sericostomatidae								
Agarodes sp.	L	L	29.7	32.4	8.1	5.4	L	

SITE #3 (continued)

Taxa	Collection Dates (1979-80) Aug***	Sept*	Oct	Dec	Feb	April	May*	June
PLECOPTERA								
Capniidae								
Allocapnia sp.			32.4	13.5	2.7			5.4
Perlidae								
Perlesta sp.				2.7				
ODONATA								
Coenagrionidae								
Enallagama sp.						2.7		2.7
Cordulegastridae								
Cordulegaster sp.					2.7			
Gomphidae								
Gomphus sp.	K			13.5	70.2	40.5		13.5
Progomphus sp.	K		13.5					
EPHEMEROPTERA								
Baetiscidae								
Baetisca sp.					10.8			
Baetidae								
Baetis sp.				2.7	2.7			5.4
Ephemerellidae								
Danella sp.				24.3	24.3			
Ephemeridae								
Hexagenia sp.	K			5.4	32.4			
CRUSTACEA								
Decapoda								
Palaemonetes sp.	K				8.1			
Procambarus sp.	K		5.4	2.7	2.7	16.2		2.7
Isopoda								
Asellus sp.			21.6	16.2	5.4			

SITE #3 (concluded)

Taxa	Collection Dates (1979-80)							
	Aug***	Sept*	Oct	Dec	Feb	April	May*	June
Amphipoda								
Gammarus sp.			13.5	13.5	8.1	10.8		8.1
ANNELIDA								
Oligochaeta	K		16.2	21.6	16.2	8.1		8.1

SITE #4

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
DIPTERA								
Ceratopogonidae				18.9	2.7			2.7
Chironomidae								
Ablabesmyia sp.					51.3			10.8
Cardiocladius sp.				16.2				
Cricotopus sp.				16.2				
Cryptochironomus sp.				16.2	29.7			10.8
Eukiefferiella sp.	27.0		8.1		29.7			137.7
Phaenospectra sp.	16.2							10.8
Polypedilum sp.			8.1	51.3	83.7			105.3
Procladius sp.					21.6			10.8
Rheotanytarsus sp.			8.1	8.1	10.8			56.7
Stenochironomus sp.								27.0
Stictochironomus sp.				16.2				
Tanypus sp.			5.4					
Thienemannimyia sp.	16.2		5.4					
Unidentified Genera						59.4		
Tabanidae								
Tabanus sp.	2.7			2.7				
Tipulidae								
Brachypremna sp.								2.7
Hexatoma sp.			8.1	21.6	10.8			5.4
Limnophila sp.					5.4			
COLEOPTERA								
Elmidae								
Stenelmis sp.	13.5		59.4	67.5	75.6			64.8
TRICHOPTERA								
Brachycentridae								
Brachycentrus sp.		L	5.4	5.4				
Calamoceratidae								
Anisocentropus sp.	L		13.5	5.4	10.8		L	10.8

SITE #4 (continued)

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
Hydropsychidae								
Cheumatopsyche sp.	L	L					L	
Hydropsyche sp.	L	L		2.7			L	
Hydroptilidae								
Hydroptila sp.		L			5.4	2.7		5.4
Leptoceridae								
Nectopsyche sp.	L	L					L	
Oecetis sp.		L	13.5	5.4	8.1	2.7		5.4
Molannidae								
Molanna sp.		L					L	
Philopotamidae								
Chimarra sp.	L	L					L	
Polycentropodidae								
Nyctiophylax sp.							L	
Sericostomatidae								
Agarodes sp.	5.4 (L)	L	24.3	32.4	27.0	2.7	L	16.2
PLECOPTERA								
Capniidae								
Allocapnia sp.	29.7		32.4	5.4				2.7
Perlidae								
Acroneuria sp.	L							
Perlesta sp.	2.7							2.7
ODONATA								
Coenagrionidae								
Enallagma sp.			2.7					
Gomphidae								
Gomphus sp.	21.6		32.4	5.4	8.1	8.1		5.4
Progomphus sp.				2.7				
EPHEMEROPTERA								
Baetiscidae								
Baetisca sp.				5.4	2.7	18.9		

SITE #4 (concluded)

Taxa	Collection Dates (1979-80) Aug	Sept*	Oct	Dec	Feb	April	May*	June
Baetidae								
Baetis sp.	2.7				10.8			
Ephemerellidae								
Danella sp.	2.7			2.7	13.5	2.7		
Ephemeridae								
Hexagenia sp.	2.7							
CRUSTACEA								
Decapoda								
Palaemonetes sp.					2.7	2.7		
Procambarus sp.						32.4		2.7
Isopoda								
Asellus sp.	2.7		2.7					
Amphipoda								
Gammarus sp.	2.7		13.5	2.7	10.8			10.8
ANNELIDA								
Oligochaeta	13.5		37.8	40.5	29.7			2.7

* Light Trap collection only.

** Blank indicates that taxon was not found at the site on this date.

*** No quantitative sample.

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AUL/LSE	1
ASD/ENFEA	1
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AFATL/CC	1
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oo ALC/MMWMC	2
AFIS/INOT	1
ASD/ENESS	1
HQ TAC/DRA	1
HQ USAF/DOQ	1
HQ PACAF/DOQQ	2
TAC/INAT	1
ASD/XRP	1
USAF TRADOC SYS ANAL ACTY	1
COMIPAC/PT-2	1
HQ PACAF/OA	1
AFESC/RDV	1
AMD/RD	1
AD/SGPE	1
AD/DEEVE	1
AD/DEEVN	1
AMRL/THE	2
USDA/ARS	1
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FEDERAL ENERGY REG COMMISSION	2
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UNIV OF FL (DEPT OF ENTOMOLOGY)	1
AFATL/DLV	10

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